C. S. Sherrington

(2)

POWERS
OF THE
ROOTS OF THE NERVES,
IN HEALTH AND IN DISEASE.

LIKEWISE,

ON MAGNETIC SLEEP.

BY

HERBERT MAYO, F.R.S.
SENIOR SURGEON OF THE MIDDLESEX HOSPITAL.

LONDON:
JOHN W. PARKER, WEST STRAND.
M.DCCC.XXXVII.

POWERS

OF THE

ROOTS OF THE NERVES.

The immediate cause of my putting forth the following exposition of my views of the functions of some of the most important parts of the nervous system, has been the publication of Mr. Grainger's treatise on the structure and functions of the Spinal Cord, followed by, to me, some very interesting conversations which, after my reading that work, took place between Mr. Grainger and myself. I find that, in my former writings, (in which I have probably, too much studied conciseness,) I have failed in stating my opinions upon the points referred to, so clearly as to prevent their being misunderstood. I have, therefore, determined to re-state them in a more perspicuous manner, and apart from the inquiries with which, in my former works, they are mixed up. I may mention that I should probably have hesitated to intrude a recapitulation of the following views of those subjects upon the physiological reader, but that I believe them to be susceptible of various practical applications; and to form the basis of that true theory of the nervous system, which several sensible men in my profession have recently told me they anticipate will be discovered before long.

I wish the reader to conceive that the nervous system of man, and of all vertebral animals, consists of the following parts:—

First, of a DOUBLE CORD of nervous substance, giving origin laterally to pairs of nerves.

The longest and thinnest part of this double cord is in the vertebral canal, and is called the SPINAL CORD.

The rest of the double cord is in the cranium, the part of which immediately continuous with the spinal cord is called the MEDULLA OBLONGATA; the part beyond that, being its higher or anterior terminus, is called the TUBERCLES, THALAMI, and STRIATED BODIES.

Nerves rise in pairs from the whole length of the double cord. Those which rise from the spinal cord are called SPINAL NERVES; those which rise from the medulla oblongata, tubercles, and striated bodies, are called CEREBRAL NERVES.

The nerves, in reference to consciousness, it was discovered by the independent researches of Sir C.

Bell, M. Magendie, and myself (each having contributed his separate share to the result,) are of two kinds, and of two kinds only, one SENTIENT, or of sensation, the other VOLUNTARY, or of the will. The consideration of the other functions of these nerves, and of the nature and office of the sympathetic nerve, I exclude from the present essay.

Secondly, of hemispherical masses, called the CEREBRUM and CEREBELLUM, which are placed on the upper parts of the double cord,—that is to say, on the medulla and tubercles, of which they are, in one sense, direct productions. These parts do not originate nerves; but it should be remarked that the tubercles and striated bodies, in addition to originating nerves, are implicated in the structure of the cerebrum.

Now, not to go further back than the time of Whytt, for the dawn of sound knowledge upon the physiology of these organs, it appears that the opinion then prevailed that the lower mental endowments were, in some sort, so generally diffused through all these organs (and, indeed, through other parts of the body,) that when an animal is cut in pieces, each portion for a time retains a certain share of consciousness.

"We shall recite," says Whytt, "a few experiments and observations, from which we are led, by analogy, to conclude that the motions of the separated parts of animals are owing to the soul, or sentient principle, still continuing to act in them*."

"A frog lives, and moves its members, for half an hour after its head is cut off,—nay, when the body of a frog is divided in two, both the anterior and posterior extremities preserve life and a power of motion for a considerable time."—(Quoted from Kaau.)

"The bodies of vipers not only move two or three days after they have been deprived of their skin, head, heart, and other bowels, but are also manifestly sensible of punctures, by means of which they may made to move with great vivacity."—(Quoted from Boyle.)

I select these from many passages in the writings of Dr. Whytt, in proof that that profound physiologist was well acquainted with the fact that, after decapitation, the body will exhibit for a time phenomena which resemble those of voluntary motion; and, in addition, that he thought *those motions proceeded from some modification of consciousness remaining in the mutilated trunk.*

I. The first step towards correcter motions consisted in the impression gaining ground, that when the head is cut off in vertebral animals, all sense, feeling, and volition, are instantaneously extinguished in the body, and that the movements, which the body and limbs then exhibit, are purely automatic or mechanical. Dr. Hall and Mr. Grainger attribute the first recognition of this principle to Sir Gilbert Blane*. I remember at the period of my early medical studies, the point now before us was received as an established truth, the evidence for which then and now commonly given, and certainly of a most conclusive nature, was and is, that in men, whose spinal marrow is torn through, or cut through by accidental injuries, the lower part of the body, or that supplied by nerves which arise from the spinal marrow below the point of division, is totally without feeling, and cannot be moved by the direct volition of the patient.

---

* Works of Robert Whytt, M.D., quarto edition. Edinburgh, 1768, pp. 203-4.

---

* Dr. Grainger quotes the following expressions from Sir Gilbert Blane:—"These facts clearly show that instinctive, or rather automatic, motions may be exerted, without the intervention of the *sensorium commune;* and therefore without sensation or consciousness." I imagine, however, that Sir Gilbert Blane's views were only twilight anticipations of the truth. Contrast, for instance, with the preceding the following passage:—

"I took a young cat a few days old, and divided the spinal marrow, by cutting it across at the neck. The hind paws being then irritated by pricking them, or by touching them with a hot wire, the muscles belonging to the posterior extremities were thrown into contraction, so as to produce the motion of shrinking from injury. The same effects were observed in another kitten, after the head was entirely separated from the body. In repeating this experiment, I found that when the spinal marrow was cut through between the lumbar vertebræ and os sacrum, the posterior extremities lost their irritability, but the part below it, the tail, retained it. It might, therefore, be said, that the spinal marrow below the division served as a sensorium; but it may be answered, that when its head is cut off, its irritability remains, as appears by the motion of the ears, when pricked or touched with a hot wire; and as the extremities are also irritable, it will not be said that consciousness and sensation exist in two separated portions of the same body. *Nor can it be admitted that sensibility and consciousness may remain in the head after separation.*" —(Croonian Lecture by Sir Gilbert Blane.) 1788. *Phil. Trans.*

II. Supposing it, then, to have become gradually received, that when the spinal cord is divided, the part posterior to the division has no further participation in consciousness, the next great step was made by Magendie, whose words I shall use to describe his progress in this wonderful inquiry. I beg to say, that—without entering into the question, whether this eminent physiologist has, or has not, exceeded the *justifiable* limits (if any are so) within which the lower animals may be put to suffering, to verify important physiological conclusions, else not verifiable,—all M. Magendie's statements as to matters of direct observation, and many and surprising they are, are implicitly to be relied on. I am, indeed, sometimes disposed to draw conclusions different from those adopted by him, but his statements of facts are thoroughly accurate and faithful.

"If you remove, by successive slices, in an animal with the cranium opened, all the parts of the cerebrum, then the optic thalami, then the entire cerebellum, in such a manner that the last section shall be anterior to the fifth nerve, the animal continues to have perception (*conscience*) of all the sensations which have their seat in the face, excepting vision. It continues to be as vividly affected by sounds, smells, tastes, punctures of the face, as if it had experienced no further injury than the loss of blood attending the opening of the cranium. If, for example, you pluck a hair of the whisker, or apply a pungent acid to the nose, it tries with its fore feet to disembarrass itself of the cause of its pain, as if it were unmutilated. Respiration and circulation take place; the movements of the body are not more interfered with, than if the cerebellum alone had been removed. And as long as the continuity of the fifth pair with the segment of its insertion is not interrupted, these phenomena continue. I have seen them in hedge-hogs last more than two hours."

"The sensibility of the trunk andlimbs has, besides, suffered no alteration. The animal cries and agitates itself, endeavours to withdraw itself and to defend itself, when a toe or the sole of the foot is pinched, equally as when the lips or the nose are injured."

"These impressions on the trunk terminate (*aboutissent*) thus at the same point with those of the face, and of the organs of the senses except the eyes."

" And this place of reunion of all the sensations of the body, except sight, is the segment of the lobe of the fourth ventricle (medulla oblongata). For a section of the cord behind the medulla oblongata, deprives the animal of the perception of all impressions made upon its trunk; which may yet be thrown into convulsive action, without the animal's perception being excited, or its uttering a cry; while, during these convulsive actions of the hinder part of the body, pricking its face causes it to do so."

" But the whole extent of the medulla oblongata is not equally the seat of this perception. If behind the insertion of the fifth pair, and *on one side only*, the upper fasciculi of the medulla oblongata are divided, the phenomena above described are not reproduceable on that side, the perception of all the sensations before excitable continuing on the other; on the other hand, dividing the lower part of one half of the medulla oblongata, does not prevent perception of sensations excited in the face. Thus the intermediate parts of the medulla oblongata are neither conductors (to the other side), nor are they the seat of perception, which, besides, seems to have two centres (one for each half of the face and body). For the division of the right half of the medulla oblongata allows perception to remain on the left side, and vice versâ. After thus looking to the transverse limits of these centres, we may examine the longitudinal limits. *The limit in front appears to be the roots of the fifth pair*[*]."

The conclusions of Magendie and Desmoulins, drawn from the preceding and other similar facts are, that "IT IS IN THE MEDULLA OBLONGATA THAT IN ALL (VERTEBRAL) ANIMALS THE PERCEPTION OF ALL SENSATIONS, EXCEPT THAT OF SIGHT, TAKES PLACE; and in addition, in which resides, in reptiles, the faculty of determining or of willing[†]."

The reader will not fail to observe the singular superiority which is in this passage attributed to the medulla oblongata of reptiles. The following quotation throws a clearer light upon this supposed difference between reptiles, and other vertebrata.

"In frogs, toads, vipers, and snakes, not only does the perception (*la conscience*) of sensation survive the destruction of the cerebrum and cerebellum; but the animal likewise continues to determine and to will, which a mammiferous animal (so mutilated,) does not do. The faculty of willing and of determining resides then, at least in part, in the medulla oblongata in all reptiles, since it manifests itself when there is no longer a brain. This force evidently has not the same seat in mammalia. But since these two forces have not the same locality, and that one may exist without the other, they are not identical. To will and to determine, are then another (a separate) phenomenon, to having the perception of a sensation*."

---

[*] Magendie et Desmoulins, des Systèmes Nerveax des Animaux à Vertèbres, p. 560.

[†] Magendie et Desmoulins, op. cit. 575.

III. Magendie thus had enunciated and experimentally shown the importance of that part of the medulla oblongata, in which is the ROOT of the fifth nerve, to the perception of all sensations, but those of sight, (in this exception he was wrong.) And I have not hesitated to attribute to him all the honour of this discovery; although other evidence had led physiologists to approach to such a conclusion. The evidence to which I allude, is that which the history of infants, born without either cerebrum or cerebellum afford: of these, the most satisfactory was communicated to the Medico-chirugical Society, by Mr. Lawrence; and some time anterior to Magendie's experiments, in an article in the *Edinburgh Review*, written, I believe, by the late Dr. Gordon, the general conclusion had been drawn from that case, which Magendie arrived at by experiment; namely, that the cerebrum, cerebellum, and tubercles, are not necessary to sensation.

In the second part of my "Anatomical Commentaries," (p. 138,) published in 1823, there further occurs this passage, showing a still closer approximation to Magendie's inferences. "From the history of acephalous infants, which have survived their birth for a short period, it appears that movements resembling instinctive movements, have been performed by human beings in which the cerebellum and the hemispheres of the cerebrum were wanting." I beg to observe that, by instinctive movements, I meant then and now, certain movements following sensation, and executed by the will. So (p. 136,) I have defined instinct to be "an arbitrary connexion between certain internal feelings, and the will to execute particular movements."

---

* Magendie et Desmoulins, op. cit. p. 566.

But the consideration of all these facts, and of Magendie's experiments, led me gradually to adopt a larger view, and as I conceive it to be, a juster conclusion*. I believe the segment of the medulla oblongata in which the fifth nerves arise, (or as I have here more loosely phrased it, the ROOT of those nerves,) to exert an influence, not only *downwards*, along the spinal cord, but *upwards*, likewise, towards the brain: I believe that the participation of every part of the nervous system in consciousness, depends upon its continuity by nervous substance with that segment. I believe, that the organs in which thought and reflection are seated, namely, the cerebrum and cerebellum, are as much dependent for the continuance of their functions on their continuity with the upper part of the medulla oblongata, as are those of the organs of sensation and volition which exist in the spinal cord.

---

* I pass over Magendie's mistake, as to the sense of smell not being destroyed, when the cerebrum is removed; and the distinction that he draws between the importance of the medulla oblongata in reptiles and in the higher vertebrata, which is unfounded, the same law, as I conceive, regulating both.

The experimental facts, upon which I build these conclusions, are indeed variations only of Magendie's experiments, and they depend, in part, for their force in the argument upon analogical considerations.

a. The cerebrum and cerebellum being removed from a living frog, the mutilated animal was alive and conscious, drawing its limbs up under it, moving them all harmoniously, when disturbed, like the acephalous human infant.

b. The head being cut off from a frog, the body preserved its irritability, so as to move on the skin being irritated; but the limbs were not then moved harmoniously; nor did the animal gather itself up, as in the preceding instance, nor its parts appear to have a common principle of action. But the head appeared conscious. This was still better seen in the head of a turtle; it remained perfectly sentient, and capable of voluntary motion.

c. When, in the first animal, the upper part of the medulla oblongata was lacerated, the animal became reduced to the state of the trunk of the second: consciousness had been extinguished.

d. When, in the head of the second animal, (or in the head of a decapitated turtle,) the upper part of the medulla oblongata was lacerated, all signs of sensation and life vanished instantaneously.

e. When, in a healthy frog, otherwise unmutilated, the upper part of the medulla oblongata (the ROOT, or place of origin, of the fifth nerve namely) was lacerated, both the head and body were simultaneously and instantly deprived of consciousness, at least of all movement that can be reasonably supposed to prove the continuance of consciousness.

Reasoning upon these facts, I am not disposed to conclude, with Magendie, that the upper part of the medulla oblongata is the seat of sensation, or of sensation and volition jointly; for, by the same process of reasoning, I must conclude, that the medulla oblongata is equally the seat of thought, deliberation, desire—to the manifestation of which by the cerebrum and cerebellum, the continuity of those organs with the medulla oblongata is not less necessary. Instead of adopting either of these conclusions, I think that the logical deduction from the facts which I have adduced, and others parallel to them, amounts to this only—*that the spinal cord has no part in consciousness, and that the cerebrum* *and cerebellum are equally excluded from their part in consciousness, when they are separated from the medulla oblongata.* We may deduce that the concurrence of two organs is necessary to the performance of a class of functions, from evidence which may be totally insufficient to prove what part ot those functions is performed by each.

IV. The next step consisted in ascertaining what powers reside in the different parts of the double cord, independent of the *vitalizing* influence of the medulla oblongata.

In the year 1823 I made this experiment (one of a series by which I determined the source of the actions of the iris in birds). The head of a pigeon being cut off, the upper part of the cranium was immediately, but without violence, removed with a sharp scalpel, the cerebrum and cerebellum were then likewise removed, and the medulla oblongata, leaving the tubercles only, which were in connexion with the eyes by means of the second and third nerves. (Now, the third nerves I had already determined to be the motor nerves of the iris.) I then divided the optic nerves;—when I found, upon pricking the end of the optic nerve adhering to the tubercles, that the iris contracted. *I had irritated the nerve of sensation* (now extinct,) *and the impression conveyed to the tubercles had excited there some change, which led to a motive impulse being propagated through the third nerve to the iris.*

I compared the result of this experiment made on nerves and their roots *on the cerebral side* of the medulla oblongata, with similar experiments made upon the nerves arising *on the other side* of the medulla oblongata, that is, from the spinal marrow, and I viewed them as one phenomenon. The general conclusion from these observations I stated in the following words in 1823:—"An influence may be propagated from the sentient nerves of a part to their correspondent nerves of motion, through the intervention of that part alone of the central organs of the nervous system to which they are mutually attached. Thus, in vertebral animals, in which alone the fact is questionable, when the spinal cord has been divided in two places, an injury of the skin of either region is followed by a distinct muscular action of that part. Again, if the brain is quickly removed from the head of a decapitated pigeon, excepting only the fore-part of the crura cerebri, together with the tubercle and second and third nerves, on pinching the second nerves the iris contracts."

In connexion with these observations, I perceived, and explained the law which regulates the origin of nerves. In vertebral animals, in mollusca, in the articulata, and in the higher radiata, "*the nerves of sensation and motion, which supply any given region in the body are derived from one and the same part in the nervous centre.*" The reader will not fail to see the connexion between this and the preceding principle. By this it was established, that each segment of the body is supplied with nerves of sensation and motion from one locality in the double cord; by the former it was shown that, under certain conditions, an impression made upon a nerve of sense requires that segment alone of the double cord in which it rises to be perfect, to be able to determine through its means an impulse to muscular action, that is thence propagated along the motor nerve.

Another point, however, still was wanted—it was necessary to determine whether any connexion existed independently of the vitalizing segment of the medulla oblongata, between one segment of the double cord and another. The following extract from the second edition of my "Physiology," published in 1829, will show that I had then resolved this doubt. The last fact mentioned in it, which, taken with the preceding argument, amounts to proof, is contained in Whytt; but I happened to become acquainted with it first through an anecdote communicated to me by the Rev. Blanco White. "The cords, which unite the nodules in the nervous systems of invertebral animals, we may presume are intended to transmit reciprocally the influence of the different segments of the nervous system from one to another. The white fibrous strings, which form the outside of the spinal cord in man and vertebral animals, have probably the same office. In the experiment upon a rabbit above described, the division of the spinal cord in two places produced three independent centres in the nervous system. If, in a snake, the head alone is removed, upon wounding the middle of the body the neck is raised, and bent towards the point at which the injury is inflicted."

So it was proved that the parts of the unconscious body for a while display a *certain degree of consent.*

V. The last step in the inquiry still remains to be considered. In a living healthy animal, are the voluntary muscles ever brought into action through the influence of one segment of the double cord, or of one group of segments, with the nerves arising therein, independently of the medulla oblongata, and of consciousness?

The following observations, bearing upon this point, I extract from my "Anatom. Comment." No. II. p. 17, published 1823; speaking of the muscles usually considered voluntary, I observe, "some, as the muscles of the trunk, of the limbs, and the like, are distinctly influenced by the will; in others again, as the muscles of the chest, and of the face in the expression of emotion, the influence of the will is not consciously employed, under ordinary circumstances, to produce their action; and a question arises, whether this or some other principle stimulate the muscles on these occasions. Much may be advanced on either side. On the one hand, it is clear that *an influence, independent of the will, occasionally throws voluntary muscles into action, as appears in tetanus, and other spasmodic disorders;* and is shown remarkably in the physiological experiment of irritating the skin on the lower extremities, after the division of the spinal cord in the back, when the occurrence of action limited to the muscles of the lower extremities evinces that a connexion exists, independently of the will, between sentient surfaces and the action of voluntary muscles. I have varied this experiment by dividing the spinal cord at once in the neck and in the back, upon which three unconnected nervous centres exist; and the division of the skin in either part, (and especially at the soles of the feet in the two hinder portions,) produces a convulsive action of the muscles in that part. *The same influence may then possibly regulate the unconscious actions to which these remarks relate.*"

The hypothesis which I here advanced, and so far maintained the reasonableness of, is that which has lately obtained notoriety under the name of the reflex function of the spinal cord. It is based upon the facts, which I have before mentioned, and had observed and reduced to one theory in the year 1823. Dr. Marshall Hall, who invented the term, "reflex function," has followed out the idea with great diligence, and has made several interesting and new experiments, showing *fresh* instances, parallel to my own published some years before, of the independent action of the segments of the double cord, and of their nerves.

To myself this hypothesis, when it originally passed through my own mind, offered no attractions. I thought that the muscular actions of the human body in health (excepting the vital motions of the viscera,) were better explained, by supposing consciousness to be at the bottom of all, than by supposing volition to regulate some, and a different principle others. I thought that this view accorded more with the simplicity of nature, more with anatomical structure, more with probability. The following passage from Whytt, which to my ear rings like true metal, expresses exactly the opinions which I have adopted.

"The necessity of air and aliment commences with our birth; and as we are excited to take in meat and drink by the uneasy sensations of hunger and thirst, which, as faithful monitors, never fail to warn us when these are wanted, but immediately cease upon the appetite's being satisfied; so, to prevent our danger of perishing through the the want of fresh air, there arises, unless the action of breathing be continually repeated, and new supplies of fresh air thus brought into the lungs, an uneasy sensation, which may not be improperly termed the APPETITE of breathing.

" If then an appetite for fresh air be as natural to animals after birth as a desire for aliment, and if none ever thought of accounting either for sensations of hunger and thirst, or for the taking of food consequent on them, *merely from the mechanical construction of the stomach, gullet, and fauces*, without having recourse to the mind; why should we attempt to explain the action of respiration from principles purely mechanical, and deny the perception and operation of a sentient active principle to be the cause, which at first begins, and can after continue it? I should think that the analogy were too strong not to strike every unprejudiced mind*?"

"The objection against the mind's being concerned in the [vital and other]† involuntary actions, drawn from our not being conscious of its interposing for that purpose, is removed, by considering that many, even of the voluntary motions, are performed, when we are insensible of the power of the will excited in their production. Thus, while in walking, we either meditate by ourselves, or converse with others, we move the muscles of our legs and thighs, without attending to it, or knowing what we are doing. We are not sensible of the eyelids being kept open by the continued operation of the will; but yet, when drowsiness and sleep steal upon us, we find it requires a considerable effort to prevent the falling down of the *superior palpebræ.* The same thing is true of the action of the muscles which support the head. The most probable account of our ignorance of these things seems to be this; viz., that we not only acquire, through habit, a faculty of performing certain motions with greater ease than at first, but also in proportion as this facility is increased, we become less sensible of any share or concern the mind has in them. Thus, a young player upon the harpsichord, or a dancer, is at first solicitous about every motion of his fingers, or every step he makes, while the proficients or masters in these arts perform the same motions, not only more dexterously, but almost without reflection or attention to what they are about."

---

* Whytt's Works, 4to., p. 110.

† I have bracketed his single mistake.

I am satisfied to suppose with Whytt, that instinctive actions are voluntary; that they proceed from sensation, and that they flow from the will, set in motion by a determined law.

So in deglutition, when the morsel reaches the root of the tongue, I prefer to think that the lingual branches of the glosso-pharyngeal nerve carry a sensation to the medulla oblongata, from which, by an instinctive law, a voluntary impulse is issued along the pharyngeal branches of the same, and of other nerves, to the muscles of swallowing. I prefer this, and think it more likely, than that the process is automatic and withdrawn from the will, and the like.

For all *practical purposes* it is evidently the same, which conclusion we adopt, *when we have admitted, that in abnormal cases, there may be an action of the circle without sensation and volition;* and such I assumed to be the case in the extract which I have last given from my "Anatomical Commentaries," in p. 20 of this essay.

Having come to the conclusion, that sensation and volition, guided by instinct, regulated the *disputable* actions of the voluntary muscles in health, I followed out in detail the influence of the nerves of sensation in this function; I may give the results in a passage from the third edition of my "Outlines of Physiology," published in 1833, p. 219; the reader will see in it an extension of the original law, respecting the place of origins of nerves, which I had pointed out several years previously.

"I believe that the observation will be found to be correct, that nerves of motion take their rise from the same region or segment with those sentient nerves which transmit the impressions, by which their action is usually regulated. The correctness of this remark, as it respects the spinal nerves, will not be disputed. In the preceding figure, the third and fourth nerves, one of which governs the motion of the iris, while both guide the eye to suit the wants of vision, are seen to rise near the optic; but the principle which I have laid down, is more strikingly illustrated by referring to the origin and uses of other nerves."

"We observe that the smaller portion of the fifth rises from the upper part of the medulla oblongata, close upon the greater portion; and we recollect, that the sense of pressure upon the teeth and gums, and of muscular exertion attending upon it, depends upon the latter, the muscular effort itself upon the former."

"We observe, that the large root of the fifth and the portio dura rise together; and we recollect, that the delicate sense of touch upon the eye and eyelids depends upon the first, and the action of the orbicularis palpebrarum upon the second; that the sense of touch in the nostrils depends upon the first, and the action of the muscles of the nostrils upon the second; that feeling in the lips depends upon the first, and the action of the muscles of the lips upon the second; and, finally, that the sensation of these muscles, which the second sets into action, depends upon the first."

"We observe that the portio dura rises near the portio mollis; and we recollect that the motions of the ear depend upon the former, and the sense of hearing upon the latter."

"We observe again, that the sixth nerve rises near the fifth; and we recollect, that it directs the eye outwards towards the orifice of the lachrymal gland, the secretion of which is under the control of the fifth."

"It is unnecessary to point out, in detail, how completely the glosso-pharyngeal and the pneumogastric nerves support the principle which I have endeavoured to establish. That every nerve cannot be arranged under it (for I know not by what means it can fairly be made to include the first and ninth) does not, I hope, render the observation valueless."

I trust, that with the comments which I have thus made, the views which I have concisely stated in my other writings as to the elementary functions of the nervous system, and especially of those of the segments of origin, or ROOTS OF THE NERVES, taken either separately, or in isolated groups, or in subservience to the medulla oblongata, will be now intelligible enough, and appear to harmonise with the theory of the remaining parts of the nervous system, the whole of which I have collected in the fourth edition of my "Outlines of Physiology."

I shall now proceed briefly to enumerate the powers of the roots of the nerves *in disease*, or the corollaries explanatory of symptoms, which may be deduced from the fact proved by my experiments added to those of older physiologists, that *each segment of the double cord, with the nerves arising* *from it, contains the entire mechanism of sensation, instinct, and volition, although these endowments in the otherwise perfect state of the segment are not manifested, unless it be in continuity with the medulla oblongata.*

The instances, which I have to enumerate, are of two kinds,—in one, the segments of origin are raised to a præternatural excitability; in the other, their force and excitability are lowered.

I. To the first class evidently belongs chorea, or St. Vitus's dance. This malady is often met with, in conjunction with a state of mind perfectly steady and composed. It is the mechanism of motion, which alone is disturbed. We may conclude the segments of the double cord, which originate nerves, in it to be præternaturally excitable. The patient wishes, perhaps, to nod his head, and a motival stimulus is deliberately sent down from the brain to that effect; but it falls upon highly excitable segments of origin; and off at once are sent, instead of the voluntary impulse to a single grave bend, fifty rapidly succeeding impulses to the muscles to nod the head in every direction but the right.

Tetanus, again, as I originally concluded in 1823 (see extract, page 20,) and as Dr. M. Hall has subsequently proved by an original experiment, consists in a sustained præternatural excitation of these segments.

In hydrophobia, the pathognomonic symptom of the disease flows from the same source, irritation of one segment of the double cord,—that, namely, from which the glosso-pharyngeal and pneumogastric nerves arise.

In some forms of hysteria, the influence of the same principle is equally obvious.

The convulsive attacks of infants,—spasms of the hands and feet, spasm of the glottis characterised by the crowing inspiration which attends its departure, spasmodic tension of the back and neck,—are equally palpable results of an iritated state of the segments of origin of the nerves situated in the medulla oblongata and spinal marrow.

II. The occasions in which the powers of the roots of the nerves, or of the segments in which the nerves rise, are overborne, are not so various; I shall content myself with pointing out two.

Sometimes the arms are palsied, or permanently contracted, without the lower part of the body being affected. In this case, the segments which originate the nerves of the arms have been found, upon dissection, wasted, while cords of white matter have passed over them to the lower part of the spinal cord, the segments in which had not wasted, and had preserved their powers through the continuity thus kept up with the medulla oblongata.

But nothing is so common as hemiplegia, or palsy of part, or of the whole, of one side of the body from cerebral disease. I think I have succeeded in showing how all its features may be deduced as consequences, from principles already explained, assisted by the application of another anatomical fact, which, however disputed by some, and multiplied by others, is as Santorini first stated it.

The segments of origin *habitually excited to action by impulses from the brain*,—receiving from the deliberative judgment, imagination, appetite, therein residing, the motival impulse to the will,—are liable, as I conceive, to have *their energy utterly subdued* by influences proceeding from the same source. The brain, in certain states of disease or lesion, is capable of despatching a withering influence, which strikes all power temporarily or permanently out of the segments of the cord.

Now, the channel of that palsy stroke is very evident, for the palsy affects the opposite side of the body to the side of the brain diseased. In other words, it moves along some channel, which passes over from one side of the brain to the other side of the double chord, to affect the opposite series of ROOTS of nerves. But the only channel which so crosses over is the anterior pyramid, and along it we must suppose the *palsy shock* to be conveyed. Besides this theoretical necessity, there are facts, which I have collected in my "Outlines of Pathology," to prove that this *is* the channel of transit for the palsy stroke.

The usually received opinion upon this subject is, that when a cerebral lesion produces palsy, it acts by interrupting the customary supply of sensorial or cerebral power to the spinal cord. But this opinion cannot be maintained; for if it were true, it would follow that the removal of one hemisphere of the brain, or its lateral compression in an animal, (from which a large part of the cranium had been removed,) would produce hemiplegia: and an acephalous infant, or an animal with the cerebrum and cerebellum removed, should be completely palsied, which is contrary to fact.

Another consequence of this mode of influence, were it the true one, would be, that in palsy strokes the parts the most remote from the brain would have their supply of nervous energy soonest cut off, which, again, is contrary to fact,—inasmuch as the arm is, in almost every case, struck first and more severely than the leg, and when recovery takes place, is slowest in being restored.

But if the cause of the palsy be, as I conclude it to be, an actively depressing influence, propagated from the diseased brain to the nuclei of the segments of the medulla oblongata and spinal cord, the difficulties, which attended the explanation of the symptoms upon the old hypothesis, are done away with. It is easy, on this supposition, to explain why the arm should be smitten first, and most severely; and why the leg, if smitten at all, should be the first to recover. The fasciculi of one anterior pyramid I have shown to be implicated in the closest manner with the centre of the summit of the spinal cord. A shock, transmitted through the filaments of the pyramid, would, it may be presumed, tell with the greatest violence where it would first fall, namely, on the segments of the spinal cord, which originated the nerves of the neck and arm, and would tell *down* the cord in a proportion lessening with the distance, from the insertion of the decussating fibres of the pyramid in the cord.

But how can such a shock affect the nerves and muscles *of the face*, on the opposite side to the cerebral lesion? I have shown that the fibres of the spinal cord, with which the decussating fibres of the pyramid are implicated at their insertion, in their upward course, ascend directly to the point of origin of the nerves of the face and throat. Is it surprising that the palsying shock, falling at a point so near this, and in continuity with it by reflected extension of nervous substance, should propagate *upwards likewise* its withering influence, and paralyse the seventh, eighth, ninth, and fifth nerves, one or all? But nothing is commoner than these very incidents in hemiplegia, occurring alone, or in conjunction with palsy of the arm. The lower extremity on the one hand, the orbital apparatus on the other, are the points of extreme remoteness from the centre, at which I have supposed the palsy shock to be delivered. It is remarkable, and forcibly consistent with my hypothesis, that these parts should be proportionately so much seldomer affected, than the face and arm. It has been objected to this view, that in hemiplegia, from cerebral disease, the leg is sometimes affected alone, or in a greater degree than the arm. If this occurrence were frequent, it would invalidate my hypothesis. Occurring, as it does, very rarely, it admits of many explanations; one of which is the following. Suppose the lower segments of the spinal cord to be already in themselves weaker than the upper, and disposed to fall into paraplegia; then a slight hemiplegic shock supervening would naturally produce the result observed; the weaker part would suffer first, though most out of the way of harm.

Such are the heads of the hypothetical solution of the phenomena of palsy, which I have linked with the preceding facts and principles. With it I close this commentary on the "Powers of the Roots of the Nerves," referring the reader, for a fuller consideration of their influence in disease, to my "Outlines of Pathology."

ON THE SO CALLED

MAGNETIC SLEEP.

I became acquainted with the Baron Dupotet, through Dr. Roget, and being curious to see the means by which he professed to produce the marvellous results ascribed to animal magnetism by its votaries, I invited him to visit the Middlesex Hospital, where he made trial of his art on four patients. I have since been present three times at the residence of M. Dupotet, in Orchard-street, and have witnessed the application of his method to several other patients; and I think, that what I have observed of the effects which ensued, is sufficiently curious to interest philosophical readers.

I set aside the consideration of M. Dupotet's pretensions to produce *clair-voyance*, and the like, which with the whole theory of an animal-magnetic fluid, are, of course, purely visionary. The means by which M. Dupotet acts, are the influence, sensibly exerted upon some temperaments, of stillness and silence, of the stillness of several persons around and looking on, and of the contemplation of slow and mysterious movements of the hand, executed in perfect seriousness, and with something like confidence in the minds of both parties, that an extraordinary effect is to follow.

The persons, in whom alone M. Dupotet's method has been seen by me to produce any sensible effects, have been young women, who have evidently been more or less disposed to that form of nervousness, which is called hysteria. When made upon others, the trial has proved an utter failure. In the former, again, genuine and ordinary hysteric paroxysms have sometimes been brought on by the magnetising process. But, besides these, a definite physiological phenomenon, a new condition of the system, I have certainly seen induced by the same means in three different persons. M. Dupotet identified this as the magnetic sleep; it is, however, anything rather than sleep, being a kind of stupor, or trance; and as it seems capable of being produced by the manipulations of "magnetism," with tolerable certainty, in persons of a suitable temperament,—having presented at each repetition, which I witnessed, in the same persons the same features, not however, without trivial variations in degree,—and as it is evidently capable of abuse, and possibly might be turned to use, (although of this I am very sceptical,) it may appear to others, as it did to me, not unworthy of examination.

The means employed are the following. The patient is desired to sit down. The operator then, standing or sitting at a little distance before her, raises his hand more or less horizontally to the level of her forehead, his fingers being pointed towards the patient, and at the distance of from two inches, to four, or six, or more; he then moves his hand, at the same distance from the person, down the chest, or down the arms or legs, sometimes keeping it for a few seconds steadily, or with an undulating motion, pointed towards the head, or to the pit of the stomach, or to the knee. Those looking on are requested not to move or speak unnecessarily, so as to draw off the attention of the patient from the operator.

The effect of this procedure on those who are susceptible of the so-called magnetic sleep are the following.

The patient, after a few minutes, closes her eyelids, and appears drowsy; if she is sitting upright at this period of the experiment, her head is apt to nod, upon which, she starts and opens her eyes, and is awake again. If, on the contrary, her posture is such as would allow her to go to sleep without falling, she might appear to a superficial observer to drop asleep; but this event certainly does not happen: the state, so induced, differs from sleep in the following decisive particulars.

1. In the first place, the pupil is not contracted, as it invariably is in common sleep. Upon lifting the upper eyelid, the eye sometimes indeed rolls away much as in sleep, so that the condition of the pupil is ascertainable with difficulty. On other occasions, the eye appears steadily directed for-

wards. In both cases, however, I satisfied myself that the pupil is dilated to the same degree in which it afterwards continues under the same light, when the patient has been roused out of her trance. The pupil is sensible to light, contracting when the patient's chair is turned towards the window.

2. In the second place, the insensibility is in some instances certainly more profound than in sleep. A person in this state does not appear to feel impressions which would awake a sleeping person; so, pinching the hand, or pricking it, produces no evidence of feeling, no motion of the hand, or other expression of uneasiness.

3. The position of the body does not appear as helplessly relaxed as in sleep; there seems to be more tone on the muscles, and the head and neck appear in part self-supported.

4. The patient cannot be roused from this condition as easily as from sleep. The means, which I saw M. Dupotet employ for this purpose, consisted in pressing the forehead and eyelids, and rubbing them, likewise stroking the arms and legs, blowing upon the forehead, and addressing the patient. It was evident to me, that he had to excite a good deal of sensation, *when the trance was profound*, before the patient could break it.

There were evident differences in the degree, to which each of the three persons, from whom I have drawn these observations, were affected.

One of them told me, that she remembered hearing something that was addressed to her when in this trance, (she had, indeed, answered a question that had been put to her, but not very pertinently,) but that she did not remember feeling, when she was touched.

Another of these young persons told me, that the sensation, which she experienced, was like that of going to sleep, and that she believed she went to sleep. This patient is liable to slight epileptic seizures without an *aura;* in these she sometimes loses her senses; at other times, when she is going off, by a strong exertion she dispels the fit. She told me, that the coming on of the trance, in which I saw her on three different days, was totally unlike the epileptic unconsciousness.

I am quite certain that there was no intentional deceit or collusion in these cases; neither were the persons who were the subject of the experiment in any way frightened or agitated. But it was, nevertheless, evident to me that they encouraged the stupor, into which they fell, and strove, to a certain extent, to get into it, and to maintain it; it was not, however, the less real, for being partly their own doing.

The alliance of this state with hysteria is very close, as the following instances, which occurred in some who could not be put to sleep, evinced. One young person, who was subjected to the Baron's procedure, went off in a regular hysteric fit of sobbing.

Another, considerably older, but by constitution highly hysterical, after sighing and sobbing, became fixed in a sullen stupor, with her eyes resolutely unclosed, in which state she remained for many minutes, and after being roused, fell back into it.

Another, a lively good-humoured girl, who was disposed to laugh at what was going on, was affected in a different way. Her complaint is an hysterical lameness of the right hip-joint. When the Baron directed his hands against her right leg and hip and her right arm, after a few minutes, they began to tremble and move, and at last to jump and be retracted in sudden spasmodic twitches; these motions ceased on the manipulations ceasing, and recurred on their being resumed. She stated, that the twitchings were attended, and as she supposed caused, by sensations of pricking and shooting, which she felt in the limbs at which the Baron pointed his fingers. Of course, these effects arose from the patient being highly hysterical, and her attention being drawn, (or, as old physiologists would have expressed it, from her animal spirits crowding,) to the region attacked by the magnetizer.

I hope the reader will not think these observations trivial; to myself, their verification appeared extremely interesting. In the first place, they explain the wonders of Mesmerism, without supposing utter and unprincipled falsehood, or egregious folly, in all the parties who have professed a belief in it. I am sure that the stupor which I have described, (which is nearly allied to some forms of stupor which occasionally present themselves in disease, or arise from mental excitement in nervous persons,) may be really produced in the nervous by the means which a magnetizer uses; and likewise, that, when the stupor so produced is not profound, a person may hear and answer during its continuance;—when, if by good luck, the answer is pertinent, and its truth within the range of probability, it serves to cover a hundred blunders. Again, I have little doubt that, when the stupor is profound, a great deal of pain might be inflicted without rousing the patient. I can even suppose it, from what I witnessed, not impossible, that a surgical operation of little severity might be performed on one in this state, and the patient, on awakening, not remember having felt pain.

In explaining the nature of "magnetic sleep," I have used indifferently the terms "stupor" and "trance." Of the two, however, the latter is much the most appropriate. *The magnetic sleep is a kind of trance, into which persons who are susceptible of it may be thrown, by the influence of the imagination excited through the senses.*

London:
John W. Parker, St. Martin's Lane